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Effect of C.R. and load on Performance and Emission Parameters of VCR Diesel Engine

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Abstract: In this research paper experimentation is conducted for diesel fuel on Single cylinder 4 stroke VCR diesel Engine at various compression ratios (16,17, and 18) and variousloads(3 kg,6kg,9kg and 12kg) .Results analysis is done to study the effects of load and C.R. on performance parameters like BTE ,Mechanical efficiency and BSFC of the engine and emission parameters like CO,HC and NOx. Results shows that, engine gives better performance at higher load and higher C.R. as value of BTE is higher at higher load and higher CO and HC emissions are decreases with increase in load and C.R but NOx emissions are higher at higher load and higher values of C.R.

Keywords: VCR Engine, Brake Thermal Efficiency, Brake Specific Fuel Consumption, Nitrogen Oxides.

I. INTRODUCTION

Diesel engines have been widely used as power of engineering machinery, automobile, and shipping equipment for its excellent drivability and thermal efficiency. At the same time, diesel engines are major contributors of various types of air pollutant emissions such as Carbon monoxide (CO), Oxides of Nitrogen (NOx), and Particulate matter (PM)[1, 2].The required levels are difficult to achieve through engine design alone. To meet these stringent emission standards requires advanced diesel engine technology, exhaust gas after-treatment, and clean alternative fuels like alcohol, biodiesel, LPG, CNG, etc. for the diesel engines[3]. The introduction of oxygenated compounds such as alcohols into diesel fuel is still today the best way to have results in matter of pollution [3, 4].Ethanol is one of the possible fuels for diesel replacement in C.I. engines [5].The main obstacles of ethanol used in CI engines are -i) Its limited solubility in diesel fuel ii) low cetane number iii)Much lower dynamic viscosity than that of the diesel fuel [6].In front of these difficulties, the use of Cetane enhancers and co-solvent additives has recovered potential of the blends as a promising fuel for automotive diesel engines [7].

II. LITERATURE SURVEY

M. Lapuerta et al.(2009) have studied the blending stability and the engine emissions with ethanol (e)-biodiesel (b)-diesel blends is presented. It was found that biodiesel acts as a stabilizer component in e-diesel blends, except at low temperatures. With all of the blends tested, reductions in smoke opacity and particulate matter emissions with respect to diesel fuel are obtained [9]. **Atilla Bilgin et al.(2002)** have performed the experimentation on VCR diesel engine operating on ethanol-diesel fuel blends. The engine was operated with ethanol-diesel fuel blends having 2, 4, and 6% ethanol as well as on diesel fuel alone.

The experiments were performed for the compression ratios of 19, 21, and 23. Experimental results indicate that the addition of 4% ethanol to diesel fuel increases power output & efficiency of the engine while it decreases SFC . The best efficiency was attained at the compression ratio of 21 [12] **K. Muralidharan and D. Vasudevan (2011)** have studied the performance & emission characteristics of a single cylinder ,four stroke VCR multi fuel engine when fuelled with waste cooking oil methyl ester and its 20%, 40%, 60% and 80% blends with diesel The blends when used as fuel results in reduction of CO, HC and increase in NOx emissions[13].**H. Sharon et al.(2012)** have used palm oil blends with diesel by different proportions (25%, 50% and 75%).Smoke density of B100 and B75 were lower than diesel by19% and 10% at full load[14].**Can Cinar et al.(2010)** have studied, the effects of premixed ratio of diethyl ether (DEE) on the combustion and exhaust emissions of a single-cylinder, HCCI-DI engine were investigated. NOx and soot emissions decreased up to 19.4% and 76.1%, respectively .On the other hand, CO and HC emissions increased [15].

III. METHODOLOGIES AND TECHNIQUES TO BE USED

- Design of Experiment –Selection of test to be conducted.
- Experimentation is done on single cylinder, 4 stroke, constant speed, VCR diesel engine
- Experiment is conducted at different loads say 3kg,6kg ,9kg and 12 kg and different C.R. of 16,17,and 18.
- Performance parameters Brake Thermal Efficiency(BTE) and Brake Specific Fuel Consumption are measuredat different loads and C.R.

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- Emission parameters NOx, CO, and HC are measured by the apparatus attracted to the test engine (Five Gas analyzer and smoke meter etc.)
- Analysis of the experimental data to investigate the effects of different variables.

A. Properties of Diesel fuel

Table1- Properties of diesel

S.R.	Properties	Diesel
1	Density (Kg/m^3 at 20^0 C)	840
2.	Lower heating value (MJ/Kg)	42.5
3.	Liquid viscosity (CP at 20^0 C)	3.03
4.	Auto-ignition temperature(^{0} C)	235
5.	Cetane number	45-50
6.	Oxygen content (wt%)	0

B. Experimental Setup

In this work experiments are conducted on computerized Variable Compression Ratio (VCR) engine test rig as shown in Fig.1. The setup consists of single cylinder four stroke VCR (Variable Compression Ratio) Diesel engine connected to eddy current type dynamometer for loading. The compression ratio can be changed without stopping the engine and without altering the combustion chamber geometry by specially designed tilting cylinder block arrangement. The experimental set up consist two pressure sensors, one placed inside the combustion chamber to measure the combustion pressure and the other placed in the injection nozzle to find the injection pressure. The digital encoder is placed to place the crank angle movement. The gas calorimeter is fixed to the exhaust gases to measure the heat loss through the exact gases. The test rig is equipped with airflow, fuel flow, temperatures and load measurement sensors. All the sensors are interface with computer through LABVIEW software and data acquisition card.

C. Specifications of the Engine-

- Engine- 4 Stoke single cylinder
- Rated Power – 3.5 KW
- Speed – 1500 rpm
- Cylinder Diameter – 87.5 mm
- Stroke – 110 mm
- Connecting rod length – 234mm
- Compression ratio – 12 to 18:1

Fig.1.Single cylinder 4- Stroke VCR Diesel Engine Setup

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D. Adjustment of C.R.

Different Compression Ratios are achieved by adjusting the adjuster bolt as shown in fig.2. First Allen bolts are unscrewed and then Adjuster Nut is adjusted by using spanner. Different markings are available on the CR Indicator to adjust the required C.R.(12 to 18).At last Allen bolts and lock nut are tightened before trial.

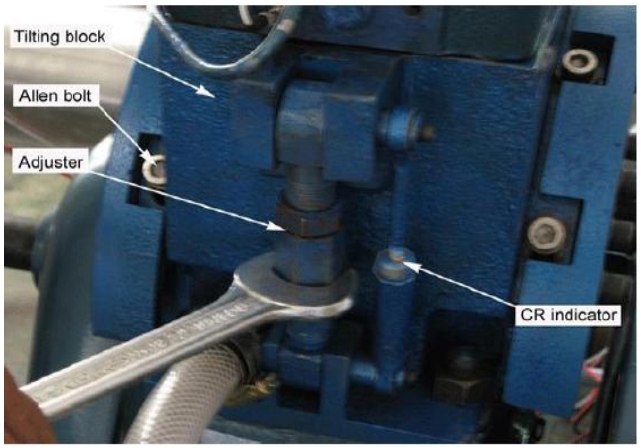

Fig.2.Compression Ratio Adjustment.

V. RESULTS AND DISCUSSIONS FOR PERFORMANCE PARAMETERS

Experimentation is conducted for pure diesel fuel at three Compression Ratios (16,17 and 18) and four loads(3kg,6kg,9kg and 12kg). Performance parameters Brake Thermal Efficiency(BTE), Mechanical Efficiency and Brake Specific Fuel Consumption (BSFC) are measured by using different apparatus connected to the test rig and the Engine Soft software.

A. Result table for performance parameters

Table 2.Observation tables for performance parameters

Load (kg)	BTE (%)			BSFC (Kg/Kwhr)		
	C.R. 16	C.R. 17	C.R 18	C.R 16	C.R 17	C.R. 18
3	16.6	16.2	18.3	0.50	0.52	0.47
6	26.2	26.9	26.6	0.33	0.32	0.32
9	30.6	30.7	31.0	0.28	0.28	0.28
12	31.7	32.2	32.8	0.27	0.27	0.27

B. Effect of load and C.R.on Performance of Engine-

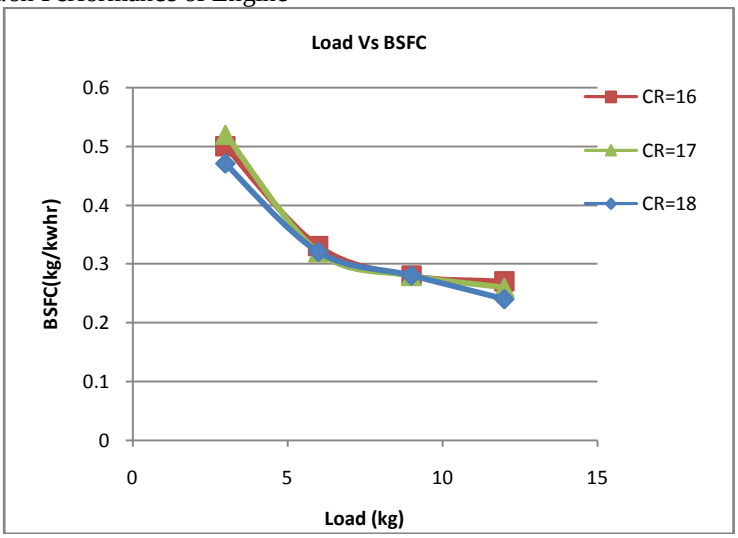

Fig 3. shows the effect of load on Brake Thermal efficiency at three values of Compression Ratios. From graph it is seen that Brake thermal efficiency increases with increase in load and BTE is maximum at 12 kg load that is at full load

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condition. This may be due to complete combustion diesel at higher C.R. and more heat is rerelease during combustion at higher C.R. Maximum value of BTE is observed at C.R of 18 and load of 12 Kg which is 32.8 %.Therefore it is better to run the engine at full load to utilize good fuel economy. Compression Ratio has very little effect on the BTE of the Engine almost at all loading range on the engine.

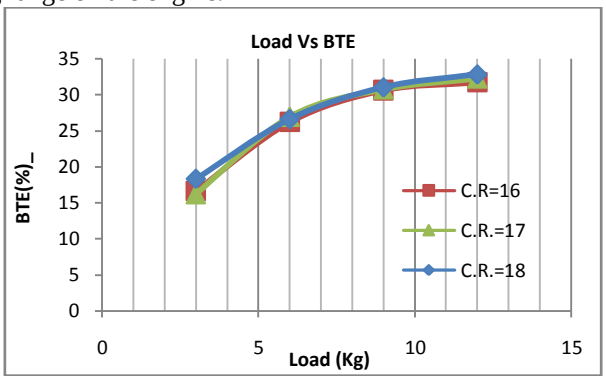

Fig.3. Effect of load and Compression Ratio on BTE

Fig 4. shows the effect of load on Mechanical efficiency of the engine at different values of Compression Ratios. The value of Mechanical efficiency increases with increase in load as frictional power almost remains same at all the values of loads and B.P. increases with load. For all the values of Compression Ratios Mechanical Efficiency almost remains same as Mechanical efficiency is mostly affected by Speed of the engine.Fig.5. shows the Effect of load and Compression Ratio on Brake Specific Fuel Consumption(BSFC). From figure it is shown that the value of BSFC decreases with increases in load due to complete combustion of fuel at higher load and higher C.R. The value of BSFC i ranging from 0.23 kg/kwhr to 0.5kg/kwhr..Also at higher loads figure shows that BSFC

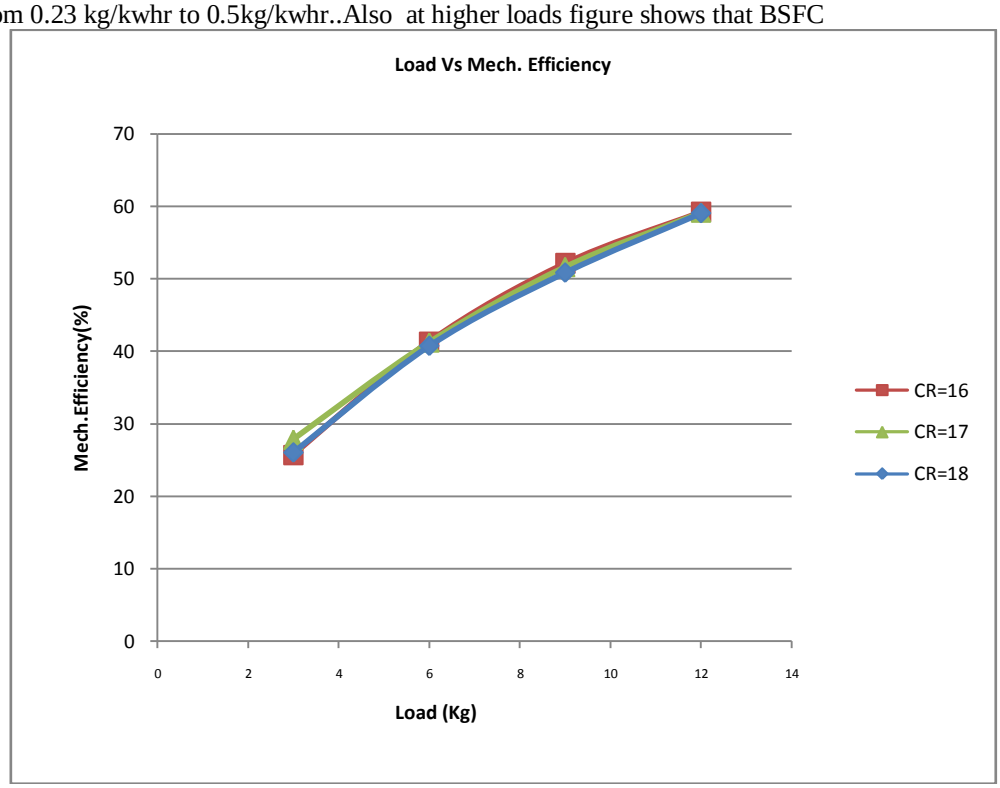

Fig..4.Effect of load and C.R. on Mech. Efficiency

Fig..5.Effect of load and Compression Ratio on BSFCalso affected by Compression Ratio. BSFC value is lowest at Compression ratio of 18 which is about 0.23 kg/kwhr.

V. RESULTS AND DISCUSSIONS FOR EMISSION PARAMETERS

Experimentation is conducted for pure diesel fuel at three Compression Ratios (16,17 and 18) and four loads(3kg,6kg,9kg and 12kg).Emission parameters like Nitrogen Oxides(NOx),Carbon Monoxide(CO) ,and unburned Hydrocarbons (HC) are measured by using five gas analyser .

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A. Observation tables for emission parameters.

Table 2.Observation tables for emission parameters

Load (Kg)	CO(%)			HC(ppm)			NOx(ppm)		
	16	17	18	16	17	18	16	17	18
3	0.160	0.095	0.064	57	38	29	129	135	228
6	0.092	0.074	0.045	55	33	25	344	345	482
9	0.054	0.049	0.018	51	32	18	692	671	495
12	0.022	0.031	0.019	31	24	22	741	720	670

VI. EFFECT OF LOAD AND C. R. ON EMISSIONS OF ENGINE

Fig. 6. shows the effect of load and Compression Ratio on CO Emission. From figure it is shown that, Carbon Monoxide (CO) emissions are decreases with increase in load. Also CO emissions are decreases with increase in compression ratio(C.R.). CO emissions also decreases with increase in load and C.R. due to complete combustion at higher load and higher C.R .Engine shows least value of CO at C.R. Of 18n and load of 12 Kg which is 0.019 % .

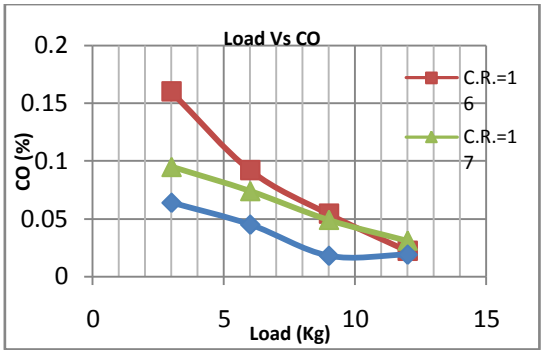

Fig.6.Effect of load and Compression Ratio on CO Emission.

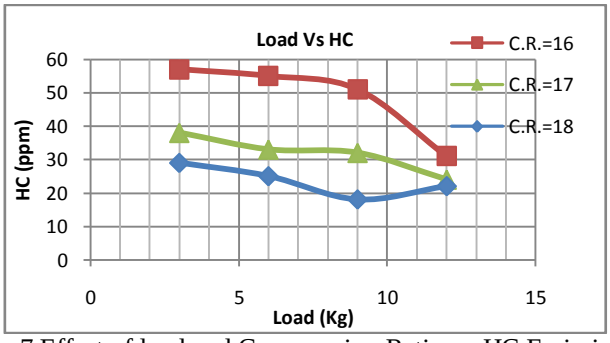

Fig.7.Effect of load and Compression Ratio on HC Emission.

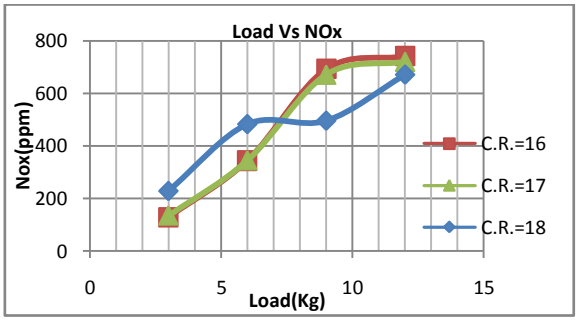

Fig.8.Effect of load and Compression Ratio on NOx Emission.

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Fig.7. shows effect of load and Compression Ratio on HC Emission. Figure shows that HC emissions are deceases with increase in load as well as increase in compression ratio. This is due to increase in combustion efficiency of the engine with increase in load and C.R. The Range of the HC emissions is about 20 ppm to 60 ppm for all values of the load.

Fig.8. shows effect of load and Compression Ratio on NOx Emission. Graph shows NOx emissions are increased with increase in the load .The normal range of the NOx emission for the engine is about 130 ppm to 700 ppm. NOx emissions are maximum at higher load and C.R. due to the higher combustion temperature.

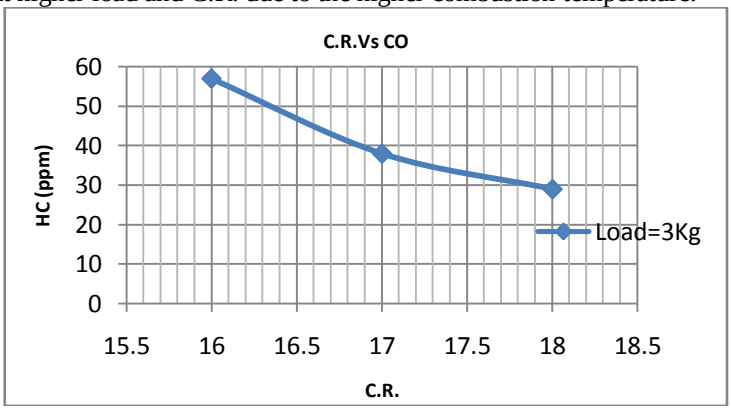

Fig.9.Effect of Compression Ratio on CO Emission.

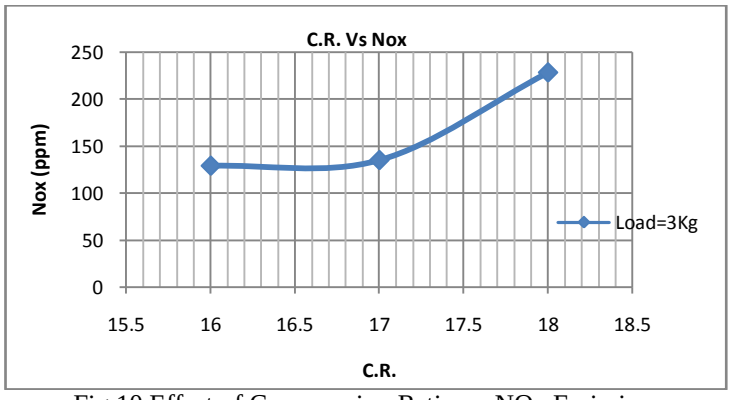

Fig.10.Effect of Compression Ratio on NOx Emission.

Fig.9. shows effect of Compression Ratio on CO Emission. From figure it is seen that with increase in C.R. CO emissions are decreased, therefore it is better to run the engine at higher C.R .From fig.10.it is seen that, NOx emissions are higher at higher values of compression ratio due to increase in combustion temperature.

VI. CONCLUSION

Following conclusions can be drawn from the experimentation for pure diesel at different values of C.R. and loads.

1) Brake Thermal efficiency and Mechanical efficiency increases with increases in load and C.R. therefore for better performance it is better to run the engine at higher load and with higher C.R.
2) BSFC decreases with increase in load that is engine gives good fuel economy at higher load and at higher C.R.
3) 3.CO and HC emissions are decreases with increase in load and increase in Compression Ratio due to complete combustion at higher combustion temperature.
4) 4.NOx emissions are higher at higher load and higher C.R. as the combustion temperature increases with increase in engine load and C.R.
5) 5. From above results it seen that, engine gives good performance at higher load and at higher compression ratio except NOx emissions.

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